Tailoring the properties of photonic crystals for light extraction in GaN

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GaN has become the prominent material for blue-green light emitting diodes (LEDs), but a significant challenge to the operation of these LEDs is the efficient extraction of light. Because of the index of refraction of GaN structures, about 90% of the light in current structures remains trapped in the material, primarily as guided modes. Our recent photonic crystal patterning of InGaN/GaN multiple quantum well material was designed to deliberately couple these guided modes into radiative modes by using a shallow, perturbative photonic crystal of 120 nm depth. Theoretical calculations predict that this approach could lead to extremely high extraction efficiencies with the appropriate photonic crystal geometry [1]. The earlier work utilized a triangular lattice photonic crystal with fixed parameters This work describes the more complete and systematic optimization of photonic crystal geometry, based on our theoretical predictions, to improve coupling and therefore increase the extraction efficiency. Characteristics of the photonic crystal including periodicity, fill factor, and hole depth as well as waveguiding properties of the structure have been varied in order to tailor the emission properties and extraction efficiency. Emission has been measured experimentally by angular-resolved photoluminescence and micro-luminescence.

[1] A. David et al., ‘Photonic bands in two-dimensionally patterned multimode GaN waveguides for light extraction’, submitted to Appl. Phys. Lett.